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Effects of Low Energy Low Protein Diet with Different Levels of Citric Acid on Growth, Feed Intake, FCR, Dressing Percentage and Cost of Broiler Production

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Abstract: *The study was conducted to observe the performance of broiler in low level of dietary nutrients by using citric acid as alternative feed additive to antibiotics. A total number of 84 day-old broiler chicks (Cobb 500) were randomly distributed into four groups each with three replicate cages having seven birds in each. Control diet (T_0=22% CP and 3000 Kcal ME/Kg) was commercial broiler where other diets contained T_1= (20.70% CP and 2790 Kcal ME/Kg+ 0.5% CA), T_2= (20.70% CP and 2790 Kcal ME/Kg + 0.75% CA), T_3= (20.70% CP and 2790 Kcal ME/Kg + 1.0% CA). The control group was supplied standard ration and the birds of T_1, T_2, and T_3 received diet with 10% less CP and ME than the control group (T_0). Feed and water were supplied on ad libitum basis. Proper bio-security measures were taken during the experimental period. The birds were vaccinated against ND on day 4 and subsequently on day 21 as booster and Gumboro at 11th day. Body weight, body weight gain and feed consumption of broilers were recorded weekly. At the end of the trial, the live weight of broiler was 992g, 1051g, 1069g and 1026g in T_0, T_1, T_2 and T_3 respectively. Significant effect was observed in live weight gain where the overall highest weight gain was observed in T_2 group. Total feed intake (g/d) was the highest in T_2 group. Best FCR was attained in T_2 which was supplied with 0.75% dietary CA and the results differed significantly ($P<0.01$) from other groups. Higher dressing percentage was observed in T_2 (69%). The overall cost per bird for T_0, T_1, T_2 and T_3 were BDT 114.83, 117.47, 119.2 and 118.86 and overall profit per bird were BDT 9.17, 13.78, 14.55 and 9.86 respectively where highest profit showed BDT 14.55 in T_2 group in which 0.75% CA was added in diet. Thus, supplementation of 0.75% citric acid in low protein and low energy diet compensated the final weight gain, feed intake and feed conversion efficiency of broiler.*

Key words: *Broiler, Citric acid, Performance.*

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I. Introduction

Poultry meat especially chicken meat is the most desirable animal protein and is acceptable by most of the people regardless of cast and religions. The poultry industry has created numerous employment opportunities (Shamsuddoha*et al.*, 2003). Short life cycle of broiler requires less capital for raising (Raha, 2006). Feed cost alone incurs 65-75% total cost of broiler production (McNab, 1999). Nearly 30% costs are attributable to supply protein in diets (Coon, 2002). The energy (Kcal ME/kg) and protein (%) levels required in broiler ration are 3135 and 21.2 for starter, 3195 and 20.2 for grower and 3250 and 17.7 for finisher respectively (Shariatmadari, 2009).

To attain increased growth of broiler within a short time, growth promoters are frequently used. Growth promoters like antibiotics, nitro furans and arsenicals are used time to time to improve meat production in chicken (Sanford, 1952). Antibiotics are often used to suppress or eliminate harmful organisms in intestine and improve growth and feed conversion (Jin *et al*., 1997).

According to an estimate of the World Health Organization, during the past decade number of deaths caused by some resistant strains exceeded the combined number of deaths caused by influenza, Human Immunodeficiency Virus and traffic accident (Yap, 2013). Considering health hazard due to residual effect of antibiotics growth promoters, the European Commission (EC) decided to phase out, and ultimately ban (1 January 2006), the marketing and use ofantibiotics as growth promoters in feed (Huyghebaert*et al.*,2011)and in the USA, consumer pressure is pushing the poultry industry to rear the birds without antibiotics (Castanon, 2007). More than 70% of the antibiotics found in Bangladesh are given to poultry in the absence of infectious diseases (Mellon, 2001).Therefore, additives acceptable to consumers and alternative to antibiotics are needed to be incorporated for using in poultry feed. Numerous products are considered and among them, organic acids appear to offer the best additive for improving the productive performance of poultry. Organic acids like acetic acid, citric acid, ascorbic acid, lactic acid, malic acid, propionic acid, formic acid, sorbic acid and fumeric acids are considered as alternatives to antibiotic growth promoter (Gunal*et al*, 2006). Several reviews have discussed the effects of dietary organic acids on broiler chickens (Dibner and Buttin, 2002; Ricke, 2003). Organic acids reduce the microbial burden of feeds by lowering pH and acting as preservatives (Mroz*et al*., 2000). By modifying intestinal pH, organic acids also improve the solubility of the feed ingredients, digestion and absorption of the nutrients (Patten and Waldroup, 1988).The European Union allowed the use of organic acids and their salts in poultry production because these are generally considered safe (Adil*et al*. 2010). The use of organic acids has been reported to protect the young chicks by competitive exclusion of food born disease (Mansoub*et al*. 2011), enhancement of nutrient utilization, and growth and feed conversion efficiency (Lückstädt& Mellor, 2011), in addition to improve digestibility of protein and mineral like calcium and phosphorus (Yesilbag and colpan, 2006; Adil*et al*, 2010,; Pirgozliev*et al*, 2008; Ao*et al*, 2009). (Park *et al*. 2009; Ghazalah*et al*., 2011) reported that organic acid improve both ME and other nutrient digestibilityof broiler diets.

Citric acid is an organic acid which is cheap and approved at European Union (EU) and it shows enough antimicrobial action to preserve the feed against bacterial spoilage, to reduce undesirable bacteria (e.g. *E. coli*.) in the gastrointestinal tract (Eidelsburger and Kirchgessner, 1994). The use of citric acid creates an acidic environment (pH 3.5 to 4.0) in the gut that favors the development of lactobacilli (Chowdhury*et al.*, 2009). Citric acid increases the digestibility of protein and fibre (Atapattu and Nelligaswatta, 2005), improves live weight gain, feed conversion efficiency, adsorption of minerals (Chowdhury, *et al.*, 2009; Shen*et al.*, 2005; Moghadam*et al.*, 2006 and Nezhad*et al.*, 2007).It reduces the available phosphorus requirement (Boling *et al*., 2000). It also decrease pH of caecal digesta (Jozefiak and Rutkowski, 2005), crop and gizzard (Andrys*et al.*, 2003) and intestine (Denil*etal.*, 2003 and Rahmaniand Speer, *2*005) in broiler chicks. It reduced microbial load (Gunal*et al.*, 2006 and Ivanov, 2001) result in better immune response in broilers (Abdel-Fattah *et al.*, 2008 and Rahmani and Speer, *2*005).

The experiment was designed to investigate the growth performance of broiler by using different doses of citric acid and to find out the probable safe and economic level of citric acid for broiler diet.

II. Materials And Methods

The experiment was conducted in Bangladesh Agricultural University, Mymensingh. Eighty four day old chicks (DOC) of COBB 500 were reared for 31 days to find out the effect of supplementary dietary citric acid (CA) in a low protein and energy diet on growth performance of chicks. All the feed ingredients and citric acid were collected from local market.

Experimental design and layout

Eighty four day old chicks were randomly divided into 4 treatment groups having 3 replications with 7 birds each. The four dietary treatment groups were T_0=control (22% CP and 3000 Kcal ME/kg), T_1= control (20.70% CP and 2790 Kcal ME/kg)+ 0.50% citric acid, T_2= control (20.70% CP and 2790 Kcal ME/kg)+ 0.75% citric acid, T_3=control (20.70% CP and 2790 Kcal ME/kg)+ 1.0% citric acid. The experiment was conducted in Complete Randomized Design (CRD). The layout of the experiment is presented in Table no 1.

Table no 1: Layout of the experiment

Replications	Dietary Treatment				Total birds
	T_0	T_1	T_2	T_3	
R_1	7	7	7	7	
R_2	7	7	7	7	
R_3	7	7	7	7	
Birds/treatment	21	21	21	21	84

Ration formulation

The control (T_0) group was supplied standard diet and the birds of T_1, T_2& T_3 received diet with 10% less CP and ME than the control group (T_0). The ingredients were bought from local market and ground individually using a grinding machine. After weighing, a part of the required amount of ground maize, soybean meal, rice polish, wheat bran, protein concentrate, meat and bone meal and oyster shell were mixed thoroughly. Soybean oil was mixed with this mixture step by step. Then the salt, Di-calcium phosphate, Vitamin-Mineral Premix, and Citric acid (except T_0) were mixed homogenously. The ingredients composition of different dietary treatments is shown in Table no 2.

Table no 2: Ingredient composition of diet (kg/100kg) in different dietary treatments

Feed ingredients	Dietary Treatment			
	T_0	T_1	T_2	T_3
Maize	56.00	56.00	56.00	56.00
Rice Polish	7.70	7.00	7.00	7.00
Wheat bran	2.25	2.25	1.80	1.45
Soybean meal	25.00	25.00	25.20	25.30
Protein Concentrate	3.80	4.00	4.00	4.00
Soybean oil	1.00	1.00	1.00	1.00
Meat and bone meal	1.00	1.00	1.00	1.00
Oyster shell	1.00	1.00	1.00	1.00
DCP	1.50	1.50	1.50	1.50
[b]Vit- Min Premix	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50
Citric Acid	0.00	0.50	0.75	1.00
Total	**100**	**100**	**100**	**100**
Energy (Kcal ME/Kg)	3000	2790	2790	2790
Protein (%)	22	20.70	20.70	20.70

Brooding

One 100-watt hanging electric bulb at chick level for cage was used tomaintain brooding temperature. The brooding temperature and humidity was measured four times in a day by an automatic digital thermo-hygrometer. For the control of temperature and light a 100 watt electric bulb was used for each cage. Electric light was provided in the trial house for 24 hours and the brooding temperature was maintained near about 34^0C for first week and decreased gradually at the rate of 3^0C in each week.

Feeding

Feeds were supplied ad-libitum as dry mash throughout the experiment period and daily feed intake was recorded.

Bio-security

All proper bio-security measures were strictly maintained during the experimental period. Movement of visitors was strictly prohibited by showing a sign board “Restricted Area, No entrance”. Entrance of animal like dog, fox etc. was controlled. Footbath (containing solution of potassium permanganate) was maintained at the entrance of the experimental house.

Vaccination

Birds were vaccinated against ND at 4^{th} day of age, Gumboro disease vaccine at 11^{th} day of age. Booster dose of vaccine for ND was again administered at 20^{th} day of age. The vaccination schedule which followed during the experimental period is given Table no 3.

Table no 3: Vaccination schedule followed for the experimental broilers

Age of birds (Days)	Disease	Name of vaccine	Route of administration and dose
4	Newcastle Disease (ND)	Avinew[R]	One drop in each eye
11	Infectious Bursal Disease (IBD)	Gumboro	One drop in each eye
20	Newcastle Disease (ND)	Avinew[R]	One drop in each eye

Clinical observation

The broilers were examined twice a day for clinical sign (slow movement, infrequent sitting, lack of appetite, significant changes of feathering, paralysis etc.) recorded as per symptoms.

Live weight gain

Broilers were weighted in a group at the beginning of the trial and then every week at the age of day 7, 14, 21 and 28. Weighing was done using electric balance before supplying feed at afternoon of each week. The average body weight gain of broilers in each replication was calculated by deducting initial body weight from final body weight.

Feed Intake

The amount of feed consumed by the experimental broilers of different treatment groups were calculated for every week by deducting the amount retained from the amount supplied in that week.

Feed consumption per week (g/chick)= [Feed supplied in a week (g) – feed weigh back in a week (g)]/No. of bird

Feed Conversion Ratio

Feed conversion ratio was calculated as the unit of feed consumed per unit of body weight gain.

Slaughtering and dressing of broiler

At the end of the feeding trail one broiler from each replication was slaughtered for determining dressing yield.

Economic study

The cost of broiler production for each treatment was calculated based on the cost of feed ingredients, chicks, citric acid, and vaccine cost. Cost for management and other costs are not considered.

Statistical analysis

All data were analyzed by using statistical SPSS (2002). Duncan's Multiple Range Test (Duncan, 1955) was done to know the differences among the treatment means.

III. Result And Discussion

Effect on Live weight

Live weight gain of the birds receiving different treatment diets are given in table no 4. At 17th days of age, the live weight of bird differed significantly ($P<0.01$) in different dietary treatment and at 24th and 31st day showed non-significant ($P>0.05$) difference in dietary treatments. At the end of the trial, the highest live weight was observed in T_2. This result is agreed with Chowdhury *et al.,* (2009), Islam *et al*., (2008) and Abdel Fattah, *et al.*, (2008) who demonstrated that addition of citric acid improved the live body weight and body weight gain of broiler.

Table no 4: The live weight (g) of broiler in different dietary treatments at different ages

Age in Days	Dietary Treatments				SEM	Level of sign.
	T_0	T_1	T_2	T_3		
	Live Weight (g)					
Day 01	35±0.40	34±0.30	33±0.35	34±0.40	0.55	**NS**
Day 10	146±1.25	145 ±0.80	143±1.75	144 ±1.16	0.645	**NS**
Day 17	291^{b}±13	326^{ab} ±17	335^{a}±12	321^{ab} ±14	8.331	**
Day 24	589±38	638±43	650±8.0	632±22	16.874	**NS**
Day 31	992±38	1051±70	1069±4.0	1026±41	25.936	**NS**

NS- Not Significant, Value indicate mean ± SD ^{abc,} means with dissimilar superscripts are significantly different (**P<0.01).

The result obtained in the present study revealed that, dietary citric acid can compensate the performance of broiler by reducing 10% energy and protein level in diet. The findings of Ziaei, *et al*. (2000) and Atapattuand Nelligaswatta, (2005) matches with the present observation, they stated that citric acid in broiler diets could improve nutrient digestibility which gave better performance and might have compensated the deficiency of protein and energy. Brzóska*et al.* (2013) reported that organic acid (0.3–0.9%) had a growth enhancing and mortality-reducing effect.

Effect on Live weight gain

Live weight gain of the birds receiving different treatment diets are given in table no 5. There was significant difference ($P<0.01$) among the group at 11-17 days of age where body weight gain was higher in T_2 (192g). The lowest body weight gain was obtained at T_0 (Control group) compared to other treatment group. Total weight gain was observed higher in T_2 (925g).

The highest weight gain on 0.75% citric acid (T_2) agreed with previous findings of Shen- *et al*., (2005); Denil*et al*., (2003) and Stipkovits*et al*., (1992) where improved weight gain was observed with addition of citric acid in diets at 0.3%, 0.5% and 0.7% respectively.

Table 5: Live weight gain (g/week) at different weeks of birds receiving different diets

Age in Days	Dietary Treatments				SEM	Level of sign.
	T_0	T_1	T_2	T_3		
Weight gain (g/week)						
Day(11-17)	145^{b}±13	181^{ab}±17	192^{a}±14	177^{ab}±13	8.46	*
Day(18-24)	298±24	312 ±21	315±17	311 ±14	11.55	NS
Day(25-31)	403±4.0	413 ±63	419 ±9.0	394 ±38	21.48	NS
Total live weight gain (g)						
	846±38	906 ±68	926 ±6.0	882±41	14.25	NS

NS- Not Significant, * P<0.05, Value indicate mean ± SD; SEM, Standard error of mean.

The result is consistent with the finding of other researches (Chowdhury *et al.,* 2009, Shen, *et al.,*2005; Ivanov, 2005 and Snow *et al.,* 2004) who reported that, inclusion of citric acid in broiler diet improve weight gain.

Weekly Live weight gain

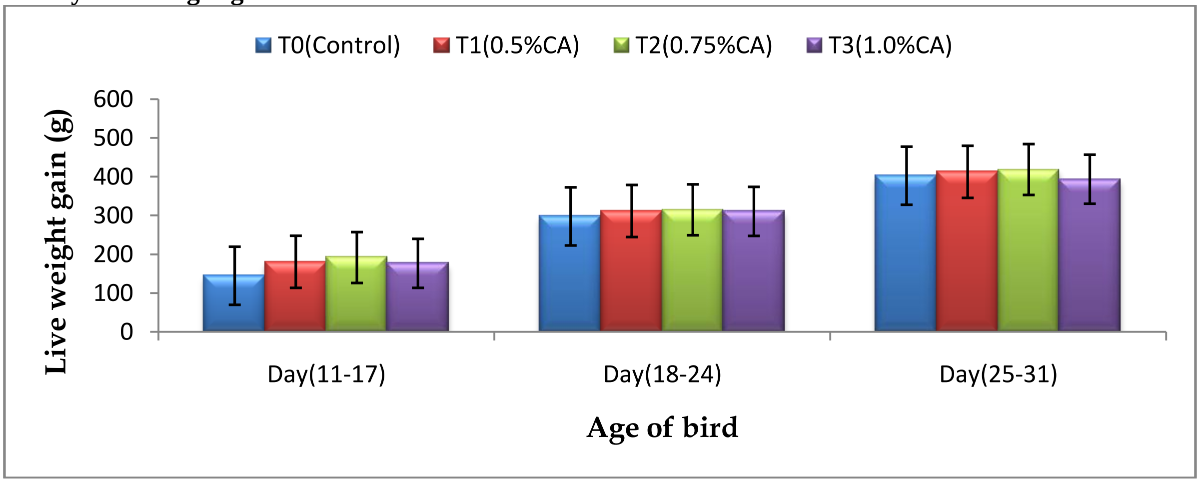

Figure no 1: Weekly live weight gains (g) at different treatment weeks of birds receiving different dietary treatments.

Effect on Feed intake

The weekly feed intake of birds of different treatment groups are shown in Table no 6. There was significant difference among the groups at 11-17 days and 25-31 days feed intake where the highest feed intake was observed in T_2 **(**P>0.05) in both cases.

The above result is similar to the findings with Islam, et al., (2008) showed that feed intake is higher by the addition of citric acid in broiler diet. These results also match with the finding of previous researchers (Darko*et al*., 1991; Frigg *et al*., 1983 and Stipkovits*et al*., 1992) where depressed feed intake was observed on higher level of CA application. However, Nezhad*et al.,*(2007) observed a non-significant effect on feed intake in broilers fed on corn soybean meal diet supplemented with the 3 levels (0.0, 2.5 and 5%) of CA that is similar to present study.

Table no 6: Feed Intakes (g\week) of birds in different weeks receiving different diets

Age in Days	Dietary Treatments				SEM	Level of Sign.
	T_0	T_1	T_2	T_3		
Weekly feed intake (g)						
Day(11-17)	187^{b}±13	190^{a}±17	207^{a}±19	192^{ab}±5.0	6.6	*
Day(18-24)	527±25	530 ±36	524±30	523±17	2.1	NS

Day(25-31)	728ᵃ±20	730ᵃᵇ±35	739ᵃ±40	715ᵇ±11	5.5	**
Total feed intake (g)						
	1442±52	1450±55	1470 ±162	1430±27	11.2	NS

NS- Not Significant, ** P<0.01, * P> 0.05, Value indicate mean ± SD; SEM, Standard error of mean.

In the present study, lowest feed intake was observed in T_3 (715g) at 25-31 days of age, this is in agreement with the findings of Cave (1984) who reported that, addition of high levels of CA would strongly decrease palatability which reduce feed intake whereas low levels increased feed intake.Moghadam*et al*., (2006) administered dietary CA (1.5 and 3.0%) and phosphorus (0.3, 0.35 and 0.4%) in broilers observed decreased feed intake.

Effect on Feed conversion efficiency

The effect of citric acid supplementation on feed conversion is presented in Table no 7. Significance difference (p<0.01) was found among the group of 25-31 days of age. The better FCR was found in T_2which treatment contained 0.75% citric acid in broiler diet and the observation is similar to Isabel and Santos (2009); Petkar*et al*.,(2011) and Afsharmanesh*and* Pourreza, (2005) who investigated that organic acid have significantly affected the feed conversion ratio (FCR). Other researches also support the observation. Celik*et al*., (2003) found better feed conversion in broiler supplementing acidifier diet and Hassan *et al*.,(2010) stated that organic acids significantly (p<0.01) improved feed conversion ratio. Celik*et al*., (2003) found better feed conversion in broiler supplementing acidifier diet. Hassan *et al*.,(2010) stated that organic acids significantly (p<0.001) improved feed conversion ratio. Isabel and Santos (2009); Petkar*et al*.,(2011), observed organic acid has significant effect on the feed conversion ratio (FCR). However, Moghadam*et al*., (2006) and (Atapattu and Nelligaswatta, (2005) reported insignificant effects of CA on feed conversion in broilers.

Table no 7: Feed Conversion Ratio (FCR) of birds in different weeks receiving different diets

Age in Days	Dietary Treatments				SEM	Level of Sign.
	T_0	T_1	T_2	T_3		
Day(11-17)	1.29±0.13	1.05±0.06	1.08±0.13	1.08±0.02	0.08	**NS**
Day(18-24)	1.77±0.13	1.69±0.07	1.66±0.13	1.68±0.02	0.03	**NS**
Day(25-31)	1.80ᵇ±0.04	1.77ᵃ±0.06	1.76ᵇ±0.11	1.81ᵃ±0.21	0.01	**
Total FCR	1.71±0.06	1.60±0.37	1.58±0.07	1.62±0.38	0.04	**NS**

Value indicate mean ± SD; SEM, Standard error of mean. [abc,] means with dissimilar superscripts are significantly different (**P<0.01).

Feed conversion ratio

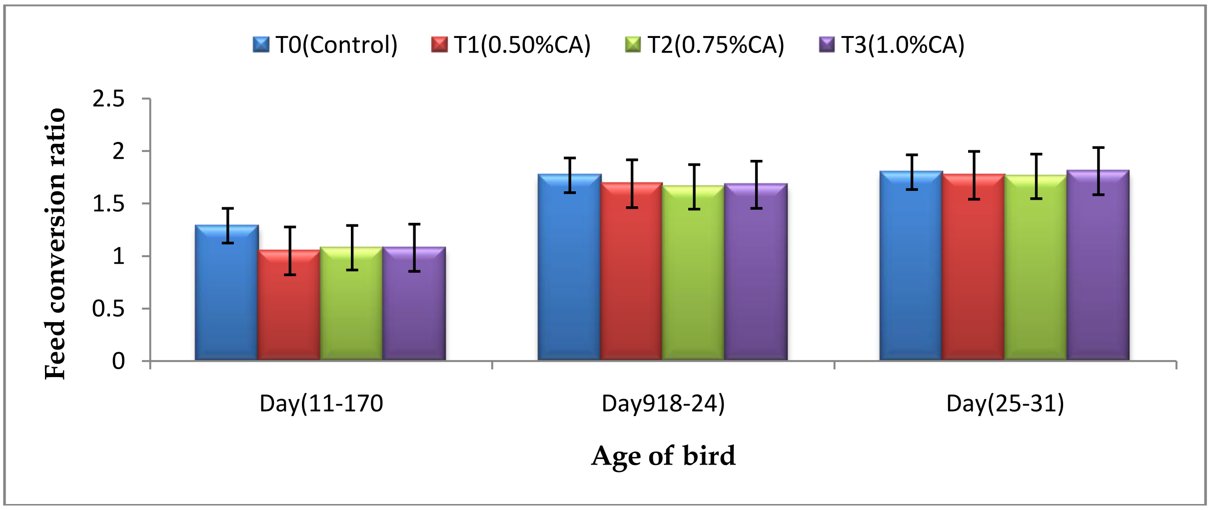

Figure no 2: Feed Conversion Ratio (FCR) Per Bird (Broiler) in Different dietary treatments

Effect of citric acid on dressing percentage of broiler

The dressing characteristics of different treatments are shown in Table no 8. It is evident that there is non-significant difference among the treatments to all parameters and only gizzard weight showed significant difference (p<0.01). The highest dressed weight was obtained in T_0 (735g) and the lowest in T_3 (665g) and there is non-significant difference among groups. The highest dressing percentage was observed in T_2 (69%) group where 0.75% Citric acid was added. The lowest dressing percentage observed in control group T_0 (65%). Dressing percentage increased with the increased level of citric acid.

Table no 8: Dressing parts development of broiler in different dietary treatments

Parameter	Dietary Treatment				SEM	Level of sign.
	T_0	T_1	T_2	T_3		
Body Weight	1092±72	1186±72	1234±72	1166±72	17.0	NS
Blood weight	42 ±3.98	42±3.98	47±3.98	43±3.98	0.72	NS
Dressed weight	735±49.21	704±49.21	709±49.21	665±49.21	8.27	NS
Viscera weight	79±4.98	69±4.98	67±4.98	63±4.98	1.91	NS
Shank weight	60±2.93	60±2.93	58±2.93	52±2.93	1.04	NS
Gizzard weight	41^{a}±2.08	33^{b}±2.08	38^{ab}±2.08	32^{b}±2.08	1.27	**
Liver weight	40±3.19	44±3.19	48±3.19	45±3.19	0.86	NS
Dressing percentage	65±0.82	67±0.82	69±0.82	66±0.82	0.21	NS

NS- Not Significant, Value indicate mean ± SD, ^{abc,} means with dissimilar superscripts are significantly different (**P<0.01).

Similar results were reported by Islam *et al*., (2008) who found that addition of organic acids (citric acid) at 0.5% in the diet of broiler chicks had no significant effect on organ weight.

Economic study of using different level of citric acid

Production cost was calculated by considering cost of bird, feed cost, citric acid cost, labor cost and other (electricity, vaccination, transportation, management) cost as shown in table no 9. Feed cost per bird was highest in T_3 where 1.0% Citric acid was added lowest in T_0. The feed cost per bird of T_1, T_2 and T_3 was higher due to the fact that with the supplementation of citric acid the feed consumption was increased. Cost per kg live weight of broilers was significantly (P< 0.01) affected by the addition of citric acid in diet. Cost per kg live weight of broiler was highest in T_0 and lowest cost per kg broiler weight was found in T_1 and T_2.

Table no 9: Economic study (in BDT) of broiler production in different dietary treatments

Parameters	Dietary treatments				SEM	Level of sign.
	T_0	T_1	T_2	T_3		
Cost/Kg feed	28.02±0.00	29.67±0.00	30.00±0.00	31.12±0.00	0.45	-
Chick price	45	45	45	45	-	-
Feed intake Kg/bird	1.6	1.6	1.64	1.57	-	-
Cost (feed/broiler)	44.83^{d}±1.01	47.47^{c}±1.10	49.2^{b}±1.20	49.86^{a}±1.21	0.79	*
Cost (feed+chick)/broiler	89.83^{d}±0.80	92.47^{c}±0.82	94.2^{a}±0.85	93.86^{b}±0.80	0.70	*
Other cost	25±0.00	25±0.00	25±0.00	25±0.00	0.00	-
Total cost/bird	114.83^{d}±0.85	117.47^{c}±0.90	119.2^{a}±0.89	118.86^{b}±0.81	0.70	*
Cost/Kg Live weight	115.76^{a}±1.07	111.87^{c}±1.01	111.40^{c}±1.02	115.39^{b}±1.08	0.81	*
Sales/bird	124±0.00	131.25±0.00	133.75±0.00	128.75±0.00	0.00	-
Profit/bird	9.17^{d}±2.01	13.78^{b}±2.10	14.55^{a}±2.30	9.86^{c}±1.60	0.96	*

Value indicate mean ± SD; SEM, Standard error of mean ^{abc,} means with dissimilar superscripts are significantly different (*P<0.05).

The profit/bird was highest in T_2 (BDT 14.55) which is followed by T_1 (BDT 13.78). Tanzin*et al*., (2015) showed increasedlevel of citric acid @ 0.75% increased profit per bird.

Profit

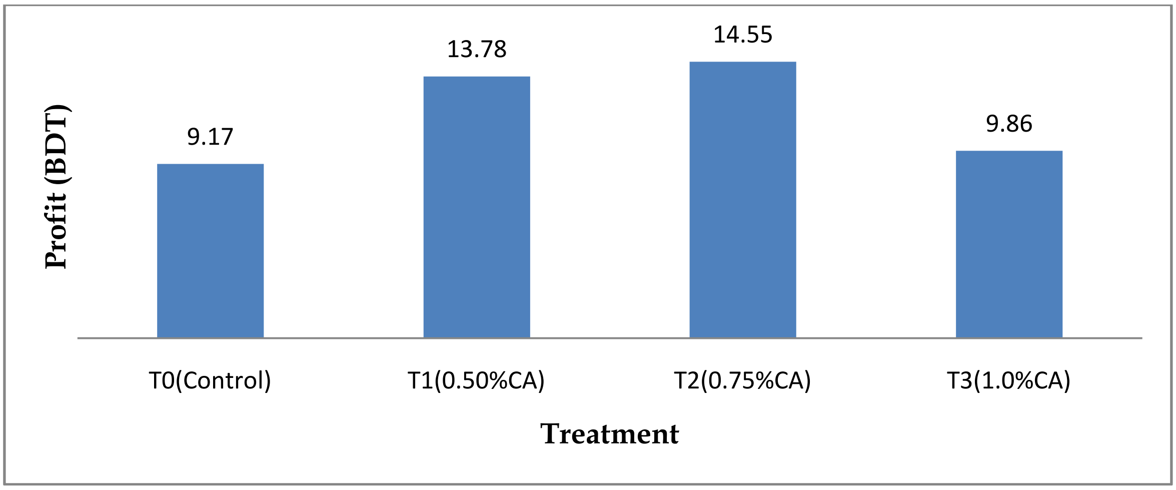

Figure no 3: Profit/kg at Economic study at different dietary treatments

IV. Conclusion

It may be concluded that citric acid supplementation at the rate of 0.75% with diet can improve the performance of broiler even under low protein and low energy concentration. Therefore, it may be recommended to use 0.75% citric acid with low protein and low energy diet for improved broiler production.

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